

THE ROLE OF APPLIED BEHAVIOR ANALYSIS IN ZOO MANAGEMENT: TODAY AND TOMORROW

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The role of zoos in conservation education and the management, propagation, and reintroduction of endangered species provides many opportunities for the application of behavior-analytic techniques. Studies of captive animals are often concerned with functional relationships between environment and behavior—the forte of applied behavior analysis.

In the daily management of their charges, animal caretakers regularly apply behavioral techniques, including shaping, use of discriminative stimuli, and varied schedules of reinforcement. However, zoo professionals have not adequately analyzed the behavioral contingencies involved in their management procedures or the consequences of the absence of natural contingencies (Forthman-Quick, 1984; Markowitz, 1982). This commentary outlines the major management tasks faced by zoo professionals as well as current and potential influences of applied behavior analysis.

CURRENT APPLICATIONS

Promotion of Species-Typical Behavior

A primary management goal of zoos is to promote species-typical behavior patterns and to discourage exhibition of behaviors that are apparent

artifacts of captivity, such as pacing, regurgitation and reingestion, and self-mutilation (Novak & Drewsen, 1989). This is critical for several reasons: First, appropriate sexual behavior is necessary for successful reproduction. Second, captive animals often have been housed in circumstances conducive to the display of abnormal behaviors. Many researchers (e.g., Sommer, 1974) have questioned the value of teaching visitors that, for example, monkeys self-mutilate. This has led to the argument that zoos should exhibit animals behaving “normally,” in order to teach conservation education more effectively. In addition, institutions housing captive animals are under pressure, legislative and otherwise, to provide for their “well-being,” for which species-typical behavior profiles are a frequently used measure (Novak & Drewsen, 1989; Novak & Suomi, 1988). Finally, expression of the full behavioral repertoire is critical to the success of efforts to repatriate endangered species. Experiments in domestication have shown that phenotypic divergence from the wild type often renders an animal incapable of survival in the wild, or at best, puts it at a competitive disadvantage (Price, 1984).

Promotion of species-typical behavior requires knowledge of environmental stimuli functioning within respondent and operant conditioning paradigms. As Garcia, Clarke, and Hankins (1973), Breland and Breland (1961), Shettleworth (1972, 1983) and others have shown, the application of behavioral principles requires consideration of each species' unique communication, social structure, and feeding strategies. Thus, knowledge of an animal's natural environment and sensory abilities is com-

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bined with an understanding of learning principles that effect appropriate changes in behavior.

Early in this century, both Yerkes (1925) and Hediger (1955) emphasized repeatedly the need for captive animals to have social and physical stimulation. Only in the past few decades, however, have these ideas been accepted. Markowitz (1978, 1982) led the way with "environmental engineering" and "environmental enrichment," wherein biologically relevant contingencies were used to effect behavior change, such as the sound of cricket vocalizations to elicit foraging in otters (*Amblonyx cinerea*) or a rapidly moving aerial "meatball" to stimulate species-typical hunting in servals (*Felis serval*). As described below, much recent research has investigated the functional relationship between the behavior of captive animals and the physical and social environment.

Physical variables. A revolution in zoo exhibit design has led to a proliferation of naturalistic exhibits. Naturalistic exhibits generally refer to those replicating as closely as possible the wild habitat of the species, including similarities in physical complexity and display of natural social groupings (Hutchins, Hancocks, & Crockett, 1984). These exhibits have had a beneficial effect on the exhibition of species-typical behavior in captive animals (Maple & Finlay, 1986). However, effects are not consistent across environments or species (e.g., Clarke, Juno, & Maple, 1982), leading to the conclusion that not all naturalistic exhibits are equal. Thus, we need a *functional* evaluation of those exhibit elements biologically relevant to a particular species. This kind of analysis results when knowledge of ethology is combined with knowledge of conditioning to identify and quantify the environmental stimuli functioning in operant and respondent conditioning.

Only recently have animal behavior researchers begun to analyze the relationships between specific exhibit elements and behavior. Much of that work is correlational (e.g., Ogden, 1992; Perkins, 1992), although the experimental analysis of constructs of environmental control (Novak & Drewsen, 1989) and cover is underway (Estep & Baker, 1991). One class of physical variables subjected to more

experimental analysis is that categorized as "environmental enrichment." Most of this work has involved feeding enrichment, wherein type of food or its manner of presentation is altered to increase time spent foraging and feeding to levels similar to those observed in the wild (see Bloomsmith, 1989, for a review). For example, we recently provided three species of bears with "fishcicles" (fish frozen in ice blocks), plain ice blocks, or fresh browse as forms of feeding enrichment. The subsequent effects on behavior were most dramatic when a female bear received fishcicles; time spent manipulating objects and feeding increased significantly and, in the second year of the study, there was a significant decrease in time spent pacing (Forthman et al., 1992).

In an elaboration of research by Bloomsmith, Alford, and Maple (1988) with chimpanzees, we provided gorillas with more frequent meals of unprocessed foods high in volume and fiber and low in palatability and quality, rather than a few meals of highly palatable, processed foods low in volume and high in quality. This enrichment regime led to a significant decline in regurgitation and reingestion (R/R) over a 6-month period (Forthman, Wood, & Gold, 1991). Ruempler (1991) and Gould and Bres (1986) also reported dramatic reductions in R/R and coprophagy after modifications in the type and quantity of foods provided to gorillas at the Cologne Zoo.

Social variables. In the past, captive animals tended to be kept alone or in pairs, regardless of what social grouping was typical for the species. Failure to address relevant social environmental cues often resulted in aberrant or inappropriate behavior. This was shown, for example, by Zuckerman's (1933) studies of aberrant behavior in a group of captive hamadryas baboons composed of a nearly equal number of males and females (rather than with one male for every three or four females) and in the work on behavioral deficits among surrogate-reared monkeys or those reared in peer groups (Erwin, Maple, & Mitchell, 1979; Harlow, Harlow, & Hansen, 1963). Zoos increasingly realize the importance of appropriate social groupings to successful captive propagation. For example, Beck and

Power (1988) determined that gorillas raised with peers as well as adults had increased reproductive success. Similarly, Stevens (1991) found flock size to be positively related to reproductive success in Caribbean flamingos, possibly because of the social facilitation of synchronous group displays.

An important factor in cases involving social variables, and one often ignored by zoo managers, is the length of the relevant reinforcement history. For example, interventions involving the behavioral consequences of hand rearing or long-term isolation have long reinforcement histories, and so require longer time scales for successful intervention. Consider, for example, the case of Willie B., a Zoo Atlanta gorilla who was wild-caught at approximately 2 to 3 years of age and was then housed alone indoors for 27 years. After completion of outdoor gorilla habitats, he was subjected to a series of behavioral interventions, beginning with solitary introduction to the outdoors, followed successively by visual and olfactory contact with other gorillas, physical contact through mesh, brief introduction to female gorillas in a neutral indoor area, and finally successful introduction outdoors, with subsequent initiation of appropriate copulatory behavior. Due to the long reinforcement history inherent in his isolation, the socialization process required almost a year to complete (Winslow, Ogden, & Maple, in press).

Reintroduction and Repatriation of Endangered Species

Another goal of animal managers is conservation of species for future reintroduction to secured habitats. Although reintroductions have been conducted with little or no evaluation, researchers more often evaluate methods and interventions necessary for successful repatriation. As always, the obstacles to be overcome in these efforts depend on the species in question. For example, birds are likely to imprint on human caretakers (Klopfer & Hailman, 1964), whereas repatriated hoofstock and small animals may be highly susceptible to predation (Konstant & Mittermeier, 1982).

One example of a repatriation effort subjected to systematic evaluation, as well as behavioral in-

terventions, is that of golden lion tamarins (*Leontopithecus r. rosalia*) in Brazil. Initial attempts showed captive-bred tamarins to be incapable of several behaviors, including eating whole food, traveling on small branches, and avoiding predators (Kleiman et al., 1986). Following these observations, the restocking protocol was revised to include interventions that forced release candidates to practice behaviors necessary to their survival. In order to learn how to maneuver from tree to tree, they are required to range freely on the grounds of the National Zoo or are kept in a "halfway house," where they learn how to navigate in a forested area but can return to the safety of nest boxes for provisioned food. Release candidates are also provided only with whole, unprocessed foods during this period (Kleiman et al., 1986).

Animal Handling

Several routine tasks of zoo professionals require handling exotic animals. The agricultural literature contains many reports demonstrating that particular handling methods are related to higher productivity and to lower stress levels among domestic species (Hemsworth, Barnett, & Hansen, 1986; Jones & Hughes, 1981; Seabrook, 1980). However, the effects of handling techniques on exotic species are virtually unexplored. A report of particular caretakers eliciting "stressed" behaviors in nonhuman primate species has recently been released (Ogden, Olson, & Miner, 1991). Markowitz and his colleagues (Line, Clarke, & Markowitz, 1987; Line, Morgan, Markowitz, & Strong, 1989) have cautioned animal managers never to presume, without supporting data, that animals have become habituated to routine procedures and handling, because their studies have demonstrated prolonged alterations in heart rate and cortisol levels after such routine procedures as cage cleaning.

Behavioral principles have been applied particularly to the task of restraining exotic animals. Previously, physical restraint was accomplished primarily with ropes and nets. The introduction of chemical immobilization reduced stress and trauma to both animals and handlers; however, chemical restraint also poses risks, particularly to sick indi-

viduals or to large animals that may suffer from hyperthermia while under anesthesia. In recent years, veterinarians have returned to physical restraint, favorably modified by the application of behavioral principles: for example, by employing squeeze cages (cages with an adjustable wall or ceiling that can be pressed against an animal inside) in conjunction with operant conditioning. Operant conditioning is used to train the animals to enter the squeeze on command, often with an auditory bridge (such as a clicker or whistle) prior to food reward. The benefits are clearly demonstrated for routine vaccinations and minor veterinary procedures (Priest, 1991).

Similarly, conditioning techniques have been employed successfully in special cases in which daily treatments or interventions are required (e.g., diabetic animals requiring daily injections of insulin: Brookfield Zoo, 1989; Priest, 1991; supplemental feeding of neonates whose mothers do not lactate sufficiently: Jendry, 1991; Priest, 1991). In such cases, chemical immobilization and physical restraint are contraindicated, because chemical restraint cannot be used safely on a daily basis, and animals required to submit to such frequent physical restraint often begin to balk at entering the squeeze cage.

A related issue is conditioning to permit collection of samples for medical diagnostics or reproductive research, such as blood, saliva, semen, urine, and vaginal cells. This typically involves shaping and systematic desensitization, often facilitated by food rewards and imitations of species-typical behavior such as vocalizations and grooming.

Pest Control

One concern specific to captive settings is that of the control of free-ranging animals typically viewed as "pests," such as rodents, pigeons, and skunks. Their presence in enclosures increases the potential for disease transmission to the captive animals. Common forms of animal control, such as pesticides, are clearly contraindicated in captive animal housing. Recently, the first author proposed the use of conditioned taste aversion to control such zoo pests. Pilot data suggest this learning paradigm

may be effective in reducing the impact of wild avian pests (Forthman, 1984); however, no conclusive studies have been conducted to date.

Animal Performances

Animal training has become far more sophisticated since the early days of circus performances, and demonstration of a species' natural history and behavior is increasingly highlighted. In our opinion, such demonstrations enhance both the performers' physical fitness and psychological health, when performed on schedules taking into account species' requirements for rest, feeding time, and seasonal reproductive aggressiveness. Such training is recommended especially for large, dangerous, and reportedly "intelligent" animals, such as elephants. These species require regular preventive veterinary care, and the relationships and operant conditioning established during training facilitate such care. Food or pats and application of an ankus (elephant hook) are used as positive and negative reinforcers, respectively, to condition responses to a set of vocal commands. These commands are then used as bridges in shaping the desired operant responses. Time-outs are typically used to extinguish misbehavior.

CONCLUSIONS

Zoos represent a largely unexplored laboratory for the application of behavior-analytic principles. Virtually all of the areas of applied learning discussed here require further quantitative analysis. The role of environmental variables in the promotion of species-typical behavior is receiving increased attention. However, functional environment-behavior relationships remain to be determined, particularly with regard to physical variables. The need to evaluate the success of species reintroduction is clear.

Complex experimental designs are more difficult to implement in zoos than in laboratories, and are further complicated by the use of largely intractable and potentially dangerous nonhuman animals. However, a rigorous systematic approach is required. Zoos also permit researchers to test labo-

ratory-developed behavioral principles in more complex settings. The effectiveness of applied behavior analysis is based on a multifaceted approach, combining behavioral observation and a rigorous experimental design. Further rigor may be achieved through analysis of physiological correlates of behavior, including monitoring of endocrine function and telemetric measurement of heart rate and body temperature (Line et al., 1987, 1989).

In conclusion, managers of captive animals are increasingly cognizant of the role of applied learning in their profession. The use of applied behavior analysis in zoos, with the scientific rigor the term implies, not only benefits the work of zoo professionals but also provides additional data on environment-behavior interactions. Finally, it enables us to come a step closer to solving some of the problems of conservation education and captive propagation—a clear mandate in the business of professional zoo management.

REFERENCES

- Beck, B. B., & Power, M. L. (1988). Correlates of sexual and maternal competence in captive gorillas. *Zoo Biology*, 7, 339–350.
- Bloomsmith, M. (1989). Feeding enrichment for captive great apes. In E. F. Segal (Ed.), *Housing, care, and psychological wellbeing in captive and laboratory primates* (pp. 336–356). Park Ridge, NJ: Noyes Publications.
- Bloomsmith, M., Alford, P. L., & Maple, T. L. (1988). Successful feeding enrichment for captive chimpanzees. *American Journal of Primatology*, 16, 155–164.
- Breland, K., & Breland, M. (1961). The misbehavior of organisms. *American Psychologist*, 16, 681–684.
- Brookfield Zoo. (1989). *Training medical behaviors in orangutans at Brookfield Zoo*. Chicago, IL: Chicago Zoological Society.
- Clarke, A. S., Juno, C. J., & Maple, T. L. (1982). Behavioral effects of a change in the physical environment: A pilot study of captive chimpanzees. *Zoo Biology*, 1, 371–380.
- Erwin, J., Maple, T. L., & Mitchell, G. (1979). *Captivity and behavior*. New York: Van Nostrand Reinhold.
- Estep, D. Q., & Baker, S. C. (1991). The effects of temporary cover on the behavior of socially housed stump-tailed macaques. *Zoo Biology*, 10, 465–472.
- Forthman, D. L. (1984). *Use of conditioned taste aversion to reduce grain consumption by avian pests in the Los Angeles zoo*. Unpublished report.
- Forthman, D. L., Elder, S. D., Bakeman, R., Kurkowski, T. W., Noble, C. C., & Winslow, S. W. (1992). Effects of feeding enrichment on three species of captive bears. *Zoo Biology*, 11, 187–196.
- Forthman, D. L., Wood, G., & Gold, K. (1991). *Decline in regurgitation and reingestion among captive lowland gorillas (Gorilla gorilla gorilla) following feeding enrichment program*. Unpublished report.
- Forthman-Quick, D. L. (1984). An integrative approach to environmental engineering in zoos. *Zoo Biology*, 3, 65–77.
- Garcia, J., Clarke, J. C., & Hankins, W. G. (1973). Natural responses to scheduled rewards. In P. P. G. Bateson & P. H. Klopfer (Eds.), *Perspectives in ethology* (pp. 1–41). New York: Plenum Press.
- Gould, E., & Bres, M. (1986). Regurgitation and reingestion in captive gorillas: Description and intervention. *Zoo Biology*, 5, 241–250.
- Harlow, H. F., Harlow, M. K., & Hansen, E. W. (1963). The maternal affectional system of rhesus monkeys. In H. L. Rheingold (Ed.), *Maternal behavior in mammals* (pp. 254–281). New York: Wiley.
- Hediger, H. (1955). *Studies of the psychology and behaviour of captive animals in zoos and circuses*. London: Butterworth's Scientific Publications.
- Hemsworth, P. H., Barnett, J. L., & Hansen, C. (1986). The influence of handling by humans on the behavior, reproduction and corticosteroids of male and female pigs. *Applied Animal Behaviour Science*, 15, 303–314.
- Hutchins, M., Hancocks, D., & Crockett, C. (1984). Naturalistic solutions to the behavioral problems of captive animals. *Der Zoologische Garten*, 54, 28–42.
- Jendry, C. (1991). Steps taken at the Columbus Zoo to support mother-rearing. *Gorilla Gazette*, 5(2), 7–9.
- Jones, R. B., & Hughes, B. O. (1981). Effects of regular handling on growth in male and female chicks of broiler and layer strains. *British Poultry Science*, 22, 461–465.
- Kleiman, D. G., Beck, B. B., Dietz, J. M., Dietz, L. A., Ballou, J. D., & Coimbra-Filho, A. F. (1986). Conservation program for the golden lion tamarin. In K. Benirschke (Ed.), *Primates: The road to self-sustaining populations* (pp. 959–979). New York: Springer-Verlag.
- Klopfer, P. H., & Hailman, J. P. (1964). Basic parameters of following and imprinting in precocial birds. *Zeitschrift fuer Tierpsychologie*, 21, 755–762.
- Konstant, W. R., & Mittermeier, R. A. (1982). Introduction, reintroduction and translocation of neotropical primates. *International Zoo Yearbook*, 22, 69–77.
- Line, S. W., Clarke, A. S., & Markowitz, H. (1987). Plasma cortisol of female rhesus monkeys in response to acute restraint. *Laboratory Primate Newsletter*, 26, 1–4.
- Line, S. W., Morgan, K. N., Markowitz, H., & Strong, S. (1989). Heart rate and activity of rhesus monkeys in response to routine events. *Laboratory Primate Newsletter*, 28, 9–12.
- Maple, T. L., & Finlay, T. W. (1986). Evaluating the environments of captive nonhuman primates. In K. Benirschke (Ed.), *Primates: The road to self-sustaining populations* (pp. 479–487). New York: Springer-Verlag.
- Markowitz, H. (1978). Engineering environments for behavioral opportunities in the zoo. *The Behavior Analyst*, 1, 34–47.

- Markowitz, H. (1982). *Behavioral enrichment in the zoo*. New York: Van Nostrand Reinhold.
- Novak, M. A., & Drewsen, K. H. (1989). Enriching the lives of captive primates: Issues and problems. In E. F. Segal (Ed.), *Housing, care and psychological wellbeing in captive and laboratory primates* (pp. 161–182). Park Ridge, NJ: Noyes Publications.
- Novak, M. A., & Suomi, S. J. (1988). Psychological wellbeing of primates in captivity. *American Psychologist*, **43**, 765–773.
- Ogden, J. J. (1992). *A comparative evaluation of naturalistic habitats for captive lowland gorillas (Gorilla gorilla gorilla)*. Unpublished Doctoral dissertation, Georgia Institute of Technology, Atlanta, GA.
- Ogden, J. J., Olson, T. L., & Miner, V. (1991). Declines in sociosexual behavior in golden monkeys (*Rhinopithecus roxellana*). *Zoo Biology*, **10**, 491–498.
- Perkins, L. A. (1992). Influence of the captive environment on the activity of orangutans. *Zoo Biology*, **11**, 177–186.
- Price, E. (1984). Behavioral aspects of animal domestication. *Quarterly Review of Biology*, **59**, 1–32.
- Priest, G. (1991). Protecting primates: The psychology of animal care, part 2. *Zoonoos*, **64**, 7–11.
- Ruempler, U. (1991). Behavior modification of lowland gorillas at the Cologne Zoo. *Gorilla Gazette*, **5**(2), 2–6.
- Seabrook, M. F. (1980). The psychological relationships between dairy cows and dairy cowmen and its implications for animal welfare. *International Journal for the Study of Animal Problems*, **1**, 295–298.
- Shettleworth, S. J. (1972). Constraints on learning. In D. S. Lehrman, R. A. Hinde, & E. Shaw (Eds.), *Advances in the study of behavior* (Vol. 4, pp. 1–68). New York: Academic Press.
- Shettleworth, S. J. (1983). Function and mechanism in learning. In M. D. Zeiler & P. Harzem (Eds.), *Advances in analysis of behaviour* (Vol. 3). Chichester, England: Wiley.
- Sommer, R. (1974). *Tight spaces: Hard architecture and how to humanize it*. Englewood Cliffs, NJ: Prentice-Hall.
- Stevens, E. F. (1991). Flamingo breeding: The role of group displays. *Zoo Biology*, **10**, 53–63.
- Winslow, S. W., Ogden, J. J., & Maple, T. L. (in press). Socialization of an adult male lowland gorilla (*Gorilla gorilla gorilla*). Gorilla Workshop Proceedings.
- Yerkes, R. M. (1925). *Almost human*. London: Johnathan Cope.
- Zuckerman, S. (1933). *The social life of monkeys and apes*. London: Kegan, Paul, French and Trubres.

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